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THE STIMULI WHICH CAUSE THE EGGS OF THE LEAF-OVIPOSITING TACHINIDÆ TO HATCH.

By Henry H. P. Severin, Harry C. Severin and William Hartung.

Some difference of opinion exists as to the stimuli which cause the eggs of the leaf-ovipositing Tachinidæ to hatch. The eggs of the leaf-ovipositing tachina contain fully developed larvæ at the time of deposition and are ready to hatch when swallowed by the host. Townsend (4, p. 109) suggests "that the digestive juices and conditions which the egg encounters in the alimentary canal of the caterpillar act upon the chitin and cause the shell to weaken so as to release the maggot." In direct opposition to this view, Swezy (3, p. 29) writes as follows: "The shell of the egg is so hard that it seems unlikely that it could be sufficiently affected by the digestive juices of the caterpillar, quickly enough to allow the maggot to escape from the egg, and also have time enough to pass through the wall of the alimentary canal before it would be carried along and be expelled with the frass of the caterpillar." Swezey (2, p. 8) first ventured the opinion that the eggs "are so small as to escape being injured by the jaws of the caterpillar in biting off bits of leaf," but in a later paper (3, p. 30) he changed his view

and believed that the mandibles of the host crack the egg-shell, allowing the maggot to escape. It appears to us that Swezey's explanation of the method of hatching of the egg is faulty in some respects. If the jaws of the host were to exert too much pressure upon the egg-shell the maggot would be crushed. Again, by what mechanism would those eggs hatch which were swallowed, but did not first have the chorion cracked by the mandibles of the host?

In order to obtain the eggs of the same species of tachinid (*Chætogædia monticola* Bigot) with which Swezey worked, a careful study of the egg-laying habits of this insect under natural conditions was made in the Hawaiian Islands. The fly usually deposits its eggs on different species of grasses and weeds. In observing the behavior of the parasitic fly, one is at first inclined to believe that the female searches for cutworms in the grass. The insect often crawls down into the thick matting of grass and disappears. Sooner or later it reappears, crawls up a blade of grass and stops a moment to deposit an exceedingly minute, black egg. As the tachinid crawls towards the tip of the blade of grass, the leaf bends, and it then grasps another blade of grass, crawls down, stops a moment to oviposit and again it may disappear in the thick matting of the grass. Occasionally the creature may rest to go through cleaning movements or to lap up some food. Often Chætogædia takes short flights, only to resume egg deposition in a new locality. When disturbed, it flies away with a loud buzz, so quickly that the eye can hardly follow it.

To obtain the eggs of this leaf-ovipositing tachinid, specimens of Chætogædia were captured in the field and placed in a glass jar provided with a cover. The bottom of the jar was covered with moist filter paper on which was placed a wet sponge. The cover was propped up with a toothpick to allow circulation of the air and thus prevent the accumulation of moisture on the sides of the jar. The food that was placed in the jar consisted of the pulp of ripe bananas and sugar. Under these conditions the flies deposited hundreds and hundreds of eggs on the moist filter paper. The pulp of the banana seemed to be especially attractive as a medium for egg-laying, for the fruit was often blackened by hundreds of tiny eggs.

A number of experiments were performed to determine whether the eggs of the leaf-ovipositing tachinid would hatch in the juices

emitted from the mouths of a number of its hosts. The bodies of army worms (*Heliophila unipuncta* Haw.) were seized between a pair of broad, pronged forceps, whereupon the larvæ ejected through the mouth a green liquid which was accumulated in a concave, center slide. One hundred eggs which had been deposited on moist filter paper by Chætogædia were emersed in this green fluid. The liquid containing the eggs was covered with a cover glass, care being exercised that no bubbles of air remained beneath the cover glass. In less than one minute some of the eggs began to hatch. Three hours later the larvæ were counted and it was found that ninety-seven of the one hundred eggs had hatched. The green liquid was tested with litmus paper and gave a decided alkaline reaction. The eggs of *Chætogædia monticola* also hatched in the akaline juices exuded from the mouths of the following hosts: *Vanessa cardui* Linn. and *Plusia chalcites* Esp.[1]

A similar experiment was performed with milkweed caterpillars (*Anosia plexippus* Linn.) from which the parasitic fly has not been bred, but the eggs hatched in the alkaline juices emitted from the mouth of the larvæ.

The eggs of this tachinid were fed to the imported cabbage worm (*Pontia rapæ* Sch.) and the larvæ of *Herse cingulata* Fab. (=*Sphinx convolvuli* Linn.) from neither of which Chætogædia has been bred. A few days later, these caterpillars were dissected and the parasitic larvæ were found embedded within the fat tissue of the body wall.

The next problem which we attempted to solve, was to determine in what part of the alimentary tract of the host the eggs of Chætogædia hatch. A caterpillar of the milkweed or monarch butterfly was fed a dozen eggs which had been placed upon a milkweed leaf. The caterpillar was vivisected immediately after the last egg was swallowed and three empty egg shells were found in the fore-intestine and nine in the mid-intestine. An army worm was vivisected and eggs of the parasitic fly were introduced into the lumen of the fore-intestine and mid-intestine. Under a binocular microscope, maggots were observed emerging from these eggs.

As there was a possibility that the digestive juices were regurgi-

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[1] *Chætogædia monticola* has been bred from fourteen different hosts in the Hawaiian Islands. "Kirkaldy (1, p. 49) reports a pupa of the butterfly, *Vanessa cardui* Linn. parasitized by this fly" and Swezey (1, p. 49) bred this tachinid from *Plusia chalcites* Esp.

tated from the mid-intestine into the fore-intestine in the caterpillars used in the previous experiment, a host was selected which did not exude a liquid from the mouth when handled. Several mature, male walking-sticks (*Diapheromera femorata* Say) were fed bits of hazel-nut leaves upon which the eggs of a leaf-ovipositing tachinid (*Phasmophaga antennalis* Towns.) were glued. Each of two walking-sticks, which had swallowed twelve eggs of the parasitic fly, was injected with 95 per cent. alcohol three hours after feeding and was then dissected. All of the eggs were found in the fore-intestine at some distance in front of the œsophageal valve but not one of the eggs had hatched. Another specimen, which had swallowed seventeen eggs, was dissected five hours after feeding. In this case, nine eggs were found in the posterior region of the fore-intestine but none of these had hatched; eight eggs were taken out of the mid-intestine in the region of the glandular appendages and seven had hatched. Only one larva was found within the contents of the mid-intestine. Upon clearing and mounting the entire contents of the abdomen, it was found that six maggots had bored through the mid-intestine; four of these were embedded in the fat tissue of the body wall and two were found in the testes.

The question naturally suggested itself, will the eggs of *Chætogædia monticola* hatch in an acid liquid regurgitated from the mouth of an insect? The liquid ejected from the mouth of a katydid gave an acid reaction, and eggs were emersed in this medium. A few minutes later one of the eggs hatched.

The blood of army worms was extracted and gave an acid reaction. From one hundred eggs emersed in this liquid, forty-five larvæ emerged. Of thirty-five eggs placed in the blood of the caterpillar of the milkweed butterfly only two hatched. It is evident than many eggs failed to hatch in the various acid media.

In another experiment the eggs of Chætogædia were emersed in the acid juices pressed from blades of grass upon which the fly deposited its eggs, but not one of the eggs hatched.

An attempt was made to hatch the eggs in a weak, alkaline solution of sodium hydroxide. After experimenting with a number of formulas it was found that 100 eggs emersed in a .1 per cent. solution of sodium hydroxide, eighty-five hatched and of the same number of eggs emersed in a .05 per cent. solution of sodium hydroxide seventy-two hatched. After the eggs had been emersed

in these alkaline solutions for twenty-four hours, some of the larvæ, still enclosed within the vitelline membrane, protruded from the egg-shells. Sometimes the posterior part of the larva within the vitelline membrane protruded from the egg-shell, whereas in a normal hatching the anterior end pushes forth from the egg. Of the two hundred eggs emersed in the alkaline solutions, twenty-seven larvæ emerged from the vitelline membrane within thirty-six hours, ninety-seven within forty-eight hours and thirty-three within sixty hours. In the experiment with the alkaline juices regurgitated from the digestive tract of the army worms, the eggs began to hatch in less than a minute, and ninety-seven of one hundred eggs hatched within three hours.

Eggs were now emersed in distilled water and results were obtained which were similar to those derived from the use of dilute solutions of sodium hydroxide. It appears, seemingly, that increased turgidity causes the larvæ to emerge when the eggs are emersed in water or dilute alkaline solutions for thirty-six hours or longer.

Is there a physiological mechanism connected with the hatching of *Chætogædia monticola?* A little pressure exerted upon the eggs of this tachinid causes the maggot enclosed by the vitelline membrane to issue from the chorion apparently uninjured. If the larvæ within the vitelline membrane is emersed in the liquid exuded from the mouths of army worms, the process of hatching can readily be observed under a microscope. As soon as the maggot enclosed within the vitelline membrane is emersed in the liquid exuded from the mouths of the army worms, bodily contractions can be observed, in a minute or less the contractions become more energetic and one can readily see the segments move from the posterior to the anterior end of the larva resembling a peristalic movement. Next the larva turns the anterior end towards the flattened or attached side of the egg so that the jaws are near the posterior end of the abdomen. The maggot then attempts to cut the vitelline membrane with the sickle-shaped part of its jaws. Often the distal end of the jaws appear to slip on the inner surface of the membrane, but once the end of the jaws is pushed through the vitelline membrane, a single sweep of the head, and the jaws cut a longitudinal incision, through which the maggot makes its way out. In pushing out of the egg-shell, peristalic movements of the body segments are again evident.

Since many of the eggs of *Chætogædia monticola* hatch in less than a minute, Townsend's view that the digestive juices act upon the chitin and cause the shell to weaken is probably incorrect. In all probability the digestive juices of the host is perceived by the larva through the micropyle of the egg and immediately the larva endeavors to free itself from the egg.

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A QUESTION OF SYNONOMY.

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For some time an Anopheline found in the eastern tropics has been accumulating names in a most unfortunate way, and as the mosquito is proven a very active carrier of malaria, and I myself am partly to blame for this multiplication of names, it seems fit I should try to untangle the synonomy.

When the study of Philippine mosquitos was in its infancy there was sent in to me an Anopheline which, according to the only authority available at the time,[1] seemed to be *Anopheles funestus* Giles. This anopheline is common in the Islands and was early seen to be so usually collected in connection with the report of malaria that in 1908[2] I noted "is taken always when malaria is present or prevalent" and this was so conspicuous that I stated "one specimen in a collection is enough to lead to a suspicion

[1] Giles G. M., Gnats or Mosquitos, 1st edition.

[2] Ludlow, C. S., Mosquitos of the Philippine Islands, the Distribution of Certain Species, and their Occurrence in Relation to Certain Diseases. 1908.